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MAR 29 1996
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BEFORE THE
Federal Communications Commission

WASHINGTON, D.C. 20554

ET DOCKET NO. 96-2

In the Matter of)	
)	
Amendment of the Commission's)	RM-8165
Rules to Establish a Radio Astronomy)	
Coordination Zone in Puerto Rico)	

COMMENTS OF CORNELL UNIVERSITY

Cornell University ("Cornell"), by its attorney, hereby comments in favor of the Commission's proposal to establish a communications Coordination Zone covering the islands of Puerto Rico, Descheo, Mona, Vieques and Culebra, all within the Commonwealth of Puerto Rico. This proposal was announced by the Commission's action in a Notice of Proposed Rule Making (FCC 96-12), released February 8, 1996. Cornell strongly urges the Commission to adopt its proposal for the following reasons:

Preliminary Statement

Cornell operates the Arecibo Observatory (the "Observatory") under a cooperative agreement with the National Science Foundation ("NSF") and as part of the National Astronomy and Ionosphere Center. The Observatory houses the world's largest radio/radar telescope which has a reflector 1000 feet in diameter, a depth of 167 feet and a primary surface collection area covering 20 acres.

The Observatory plays a leading international role as a versatile research instrument in radio physics, employing sensitive receivers, powerful planetary and ionospheric radar transmitters and sophisticated data acquisition and analysis equipment. Basic research is being conducted there in radio astronomy, radar astronomy and atmospheric science. The telescope operates 24 hours a day, each day of the year, and yet demand for its use by scientists is so heavy that there has been a backlog of approved research proposals of nearly one year. The Observatory's telescope has been used to obtain detailed radar maps of Venus, precise pulsar measurements demonstrating the

existence of gravitational radiation and of planets, and observations of hydrogen and molecules in galaxies far beyond the Milky Way. The 1993 Nobel Prize for Physics was awarded to two Princeton physicists for discoveries made in pulsar research conducted by them at the Observatory. In addition, the first extra-solar planets recently have been found with the Arecibo telescope which is the only telescope capable of making such high sensitivity detections.

The Observatory was originally designed to operate at frequencies up to 500 MHz but recently it has been used at 12 GHz. At a cost of \$22.8 million provided by NSF and the National Aeronautics and Space Administration ("NASA"), the telescope is presently being upgraded so that it will be able to make routine observations anywhere from 50 MHz up to 15 GHz and beyond. The Gregorian Upgrade is approaching its final phase and consists of three major parts. First, a 50-foot high fence has been built around the primary surface in order to block entry of ground radiation into the feed system. Second, a Gregorian subreflector system will replace the narrow band feeds formerly used. This observing system will have continuous frequency coverage from 300 MHz to 10 GHz. In combination with reduced system temperatures, the sensitivity of the world's most sensitive telescope will be increased by 50 to 500 percent. Third, a laser ranging system will be installed to accurately control position and altitude of the 900-ton observing platform and to facilitate accumulation of accurate data at the higher frequencies. At the time of submission of these Comments, the Gregorian subreflector system has been mounted below the observing platform. During the summer of 1996, the mechanical work will be completed, at which time testing and calibration of the new observing system will commence. By the end of the summer, the telescope should be usable for astronomical observations.¹ With the completion of the upgrade, observation times will be reduced by factors as high as 10, greatly enhancing the efficiency of the telescope. With the improvements in sensitivity, however, the Observatory will be even more susceptible to radio frequency interference.

The Arecibo Observatory is located approximately 17 kilometers south of the city of Arecibo in the central region of Puerto Rico, which is some 100 miles from east to west and 40 miles north to south. The longest distance from the Arecibo Observatory

¹ In addition, the Arecibo Observatory Visitor and Education Center is presently being constructed at the Observatory site and is expected to be completed September 1996. This \$2.2 million facility has received most of its funding from private donors in Puerto Rico. 100,000 visitors annually are expected to be accommodated at the Center, which will house exhibition areas for science and astronomy education, an auditorium and an observation deck overlooking the Observatory. In addition to tourists and school children, science teachers and educators are expected to take advantage of course work conducted by the Observatory staff. The National Science Foundation supports the development of the displays and education programs for the Center.

over land to the sea is only 70 miles. A central mountain range from east to west along the island shields the southeastern region of Puerto Rico from the Observatory, but despite the rugged terrain, the Observatory has direct or nearly-direct line-of-sight to 70 percent of the island territory and to most of the communications facilities authorized to operate there. Given its relatively small size, Puerto Rico is one of the most congested communications areas in the United States, a fact which the Commission noted in its NPRM.

The Arecibo Observatory enjoys very little natural shielding for radiation sources over a large fraction of the island because its observatory platform is significantly elevated above the surrounding terrain, and is thus vulnerable to signals coming from the horizon. External RF radiation has dramatically increased over the past decade and is likely to continue to increase. The harmful effects will only intensify with the greatly increased sensitivity resulting from the Gregorian Upgrade. Years ago a radio astronomer could make a secure detection of a signal during one observation. Presently, an observer must check any detection with a second or third observation in order to verify the results. The spurious interfering signals increase the time necessary to conduct research and result in wasted observing time. With the increasing demand for using the Arecibo telescope, the increased RF interference hampers research all the more.

To partially offset this degradation, the Commonwealth of Puerto Rico has established a Protection Zone with a radius of four miles surrounding the Arecibo Observatory. This Protection Zone effectively helps the Observatory to control RF interference generated in the immediate vicinity by faulty household appliances, electric fences or welding equipment. In addition, the Puerto Rican government has adopted new zoning regulations which prohibit microwave links from running through or being directed at the eight-mile diameter of the Protection Zone. Microwave links operating in the vicinity of the Observatory are now required to coordinate with the Observatory to reduce if not eliminate RF interference.

The Observatory is actively involved in steps to suppress or eradicate the access of interfering signals to the receiving systems. The design of the telescope provides a significant advantage. The extremely high forward gain of the main beam is directed upwards, never reaching an angle of more than 20 degrees from the vertical. Hence, interfering radiation from the horizon enters only through the far sidelobes, which are typically one million to one hundred million times less sensitive than the main beam.

A major feature of the Gregorian Upgrade is to reduce this sidelobe level still further. Direct line of sight access to the receiving feeds will be eliminated at frequencies above 300 MHz because the new feed system and its subreflectors are enclosed in a

shielded 83-foot diameter space frame. The enclosure entrance "pupil" accepts cosmic radiation reflected upward from the primary mirror, but is hidden from most of the incoming interference. Once line of sight access is eliminated, the scattering properties of the telescope support structure provide the only access for interfering signals. Research is being directed to ways of reducing this scattering and diffraction process. A solution to the complicated scattering problem is not easy to achieve but future technology may some day result in rendering the platform less susceptible to this phenomenon, thus "stealth" the platform from incoming RF interference. The Observatory is also diligent in using the latest receiver technology to deal with interference, which does gain access to the feeds. Cryogenic filters and new mixing schemes with low susceptibility to intermodulation are in place or under development.

Despite all these measures, the Observatory staff must still maintain a monitoring station on a 24-hour basis to assist in identification of sources of interference. A mobile station is being equipped with monitoring and direction-finding capabilities. Members of the Observatory staff are active participants in the Puerto Rico Spectrum Users Group ("PRSUG") and maintain regular contact with local private and governmental spectrum users. The Observatory's good relations with the Puerto Rico Amateur Club established a level of cooperation that persuaded Cornell to modify its original proposal to require all amateur operators to coordinate with the Observatory. Recently, an amateur chapter has been formed at the Observatory itself.

Radio astronomy observations at the Observatory continue to be hampered by the worsening interference environment in Puerto Rico. Interference levels are such that even observations conducted on RAS bands are damaged by spurious emissions. In particular, third harmonics or third order intermodulations from two-way communication and paging systems are troublesome sources. Harmonic emissions from television broadcast stations are nettlesome as well and the Observatory has occasionally submitted constructive comments with the Commission suggesting methods to eradicate such interference. The requirements for suppression of spurious emission are far more strict in the CEPT-member countries in Europe--17 to 43 dB tighter--than in the United States. Currently, Task Group 1/3 of the ITU is considering various spurious emission standards, keeping in mind the protection of the passive services, which will hopefully provide further protection to radio astronomers.

The Puerto Rico Coordination Zone

The foregoing reasons led Cornell to petition the Commission to formally require cooperation to assist the Observatory in eliminating or reducing interference to its observations. In response to the petition, the Commission has proposed to establish a

Coordination Zone within the Puerto Rico Islands, which would require applicants for new and modified communications facilities to notify the Observatory in writing so that the Observatory could determine whether the application would cause harmful interference to the Observatory's radio astronomy facilities. In the event that potential interference is expected, the applicant and the Observatory would be required to coordinate, that is, to explore what reasonable steps could be taken by the applicant to minimize if not eliminate the potential problems.

Under the rule proposed by the Commission, applicants would be required to notify the Observatory which would then analyze the applications, communicate with those applicants who potentially would cause objectionable interference, attempt to resolve objections through agreements with applicants who, in turn, "would be required to make reasonable technical modifications to its proposal in order to resolve or mitigate the potential interference problem and to file either an amendment to the application or a modification application, if appropriate." NPRM at ¶ 21. Technical information to be provided to the Observatory would include frequency, power, antenna height, antenna directionalization and gain, coordinates and type of emission which, in most cases, will be contained in the technical portion of the application.² Absent an agreement, the Observatory could file an objection within 20 days from the date of filing of the application. The Commission would not be required to accord the same "increased weight" to the Observatory's comments such as it does under the National Radio Quiet Zone (the "NRQZ") rules, *e.g.*, § 73.1030(a) of the Commission's Rules, but rather, may grant an application which would cause interference "[o]nce an applicant has satisfied its responsibility of making reasonable efforts to accommodate the Observatory...." *Id.*

While it is true that the Observatory's petition for rulemaking eschewed the same level of protection afforded to radio astronomy observatories in the NRQZ, the Observatory did not mean to concede that the need for protection would always be secondary. The Commission's proposal seems to suggest that the public interest benefits of radio astronomy research in Arecibo would not outweigh the benefits of new or modified communications services in Puerto Rico, provided reasonable effort was made by an applicant to accommodate the Observatory. Because written comments from the

² Cornell believes that in addition to these technical parameters, information concerning ground elevation at the antenna location would be useful. In addition, the name, address, telephone, facsimile and e-mail addresses of the applicant and contact person would facilitate coordination. A complete copy of the application containing all relevant information would be the preferred notification. Cornell endorses the proposed requirement that applications contain an indication of the date that the applicant notified the Observatory. In order to provide a consistent mode of operation, Cornell plans to provide comments on all applications or notifications. A simple form letter will be filed with regard to those applicants for which no interference problems are anticipated.

Observatory would be entertained under the Commission's proposal, there may be some situations where the Commission would be required to consider whether the public interest would be better served by affording protection to radio astronomy research.

Cornell now believes that the 20-day time period for such cooperation is too restricted to permit the coordination to be effectuated. A better time frame would be to permit the filing of written comments by the Observatory 30 days after issuance of a public notice of the acceptance of an application for new and modified (major and minor) operations.³ This extended period would give all affected parties time to resolve differences and, presumably, would eliminate the need in many instances to file any comments at all. This period would also alleviate the Commission's concern that a requirement to share technical data prior to the filing date would breach confidentiality. NPRM at ¶ 22. In the event that such information is provided to the Observatory in advance of the filing date, such information will be kept confidential and not made public.

The Commission's proposal does not require specification of the interference criteria to be used by the Observatory in calculating potential interference, choosing to rely, instead, on the Observatory's good faith efforts to make such evaluations and on the difficulty of identifying precise standards in differing situations. In its Reply Comments (at ¶ 16) Cornell pointed out that "the damage RFI can do to astronomical data is not uniform. It depends critically on the strength of the signal but more on where it falls in the spectrum." The ultimate criteria, of course, is ITU-R RA.769 which defines the levels of harmful interference in bands reserved for radio astronomy use ("RAS").⁴ But such criteria are only guidelines for non-radio astronomy frequencies.

A serious problem is the out-of-band and spurious emissions which originate on frequencies far removed from RAS bands but which create havoc within RAS bands. Standards governing such emissions are currently being studied by ITU TG 1/3 and should be helpful in dealing with potential problems. As such standards are refined and as new standards are developed, a Commission rule containing specific interference criteria for Arecibo would have to be occasionally updated. Cornell continues to believe that the better course is to avoid setting specific interference criteria and to permit the Observatory to employ the tools that are available in a reasonable and non-arbitrary

³ For applications which are not placed on a public notice, a 30-day period following the date of filing would facilitate the time-consuming process of coordination.

⁴ These levels are also described in the Handbook on Radio Astronomy issued by the ITU which is available to the public.

manner. It cannot be stressed too often that the Observatory's goal is to co-exist with communications facilities and not to supplant them. The Observatory will continue to be guided by what is the "reasonable effort" standard for the other spectrum users.

The Commission has proposed that coordination zone rules would apply to applicants in the following services: Parts 5, 21, 22, 23, 24, 25, 26, 73, 74, 78, 80, 87, 90, 94, 95 and 97. No reference was made by Cornell in its petition to the Personal Communications Service (Part 24) and the Wireless Communications Service (Part 26) which did not exist at the time of Cornell's filing, but Cornell supports the proposal to include these services within the ambit of the rule as well.⁵ If there is a public interest in making some provision for protection of radio astronomy research, and the Commission's proposal makes it clear that there is such a benefit, then whatever burden is placed on the affected communications services to notify the Observatory is minimal. Cornell prefers that the application itself, containing all relevant and useful information, be transmitted to the Observatory. In lieu of physically transmitting the application to the Observatory's address, applicants may wish to send the application electronically to the Observatory's computer address: prcz@naic.edu. The only means of transmission of these data which the Observatory would find unreliable would be initial oral communications which could foster erroneous technical specifications.

Although Cornell knows of no other services which should be subject to the coordination procedures under the new rules, the realities of existing interference continue to be a cause of concern. A unique capability of the Gregorian observing system at the Observatory is its high sensitivity at frequencies below 2 GHz. For this reason, the research at the Observatory will center on cosmological studies using the elements neutral hydrogen and hydroxyl. As research is conducted further back in time and distance in the universe, elements can only be observed at lower frequencies because of the Doppler affect. Researchers need to use the telescope at frequencies as low as 50 MHz to conduct these studies. Existing high power operations, particularly television stations, operate in frequencies which are crucial for these kinds of radio astronomy research, and yet such facilities are beyond the reach of the proposed rules. While there is no question that these facilities are rightfully using the spectrum licensed to them, it is reasonable to expect some cooperative efforts on the part of such stations to permit some observations to occur on occasion without interference.

One example of such voluntary cooperative efforts involved WCCV-TV in Arecibo, cited by Cornell in its petition as an example of the need for prior notification.

⁵ Cornell has no objection to imposition of the notification and coordination requirement upon Part 90 frequency coordinators rather than on the licensees.

WCCV-TV, which operates on Channel 54, has a visual frequency of 711.25 MHz. Its second harmonic falls at 1422.5 MHz, which lies within the spectral range of the neutral hydrogen emission of our Galaxy. If this second harmonic were permitted to exist, all observations at this frequency could be destroyed. Although WCCV-TV had already received a construction permit before the Observatory became aware of its existence, the Observatory and WCCV-TV cooperated by finding a technical solution--filtering and case shielding were installed by the station at a minimal cost to it. The station now operates at a full 1.5 MW power, but has second harmonic emissions at least 160 dB below the fundamental frequency and 100 dB below the spurious emission standards currently required by the Commission.

For those studies which must be conducted on frequencies assigned for television use, however, such a solution would not obtain. In those instances, time-sharing may provide resolution of the conflict. Since most stations cease broadcast operations during late evening and early morning hours, cooperation and coordination could lead to the availability of those frequencies to radio astronomers at those off-hours. For stations that operate 24 hours per day, arrangements could be made for researchers to use a few nights to conduct their studies while the stations ceased or reduced operations. Cornell recognizes that the opportunities for such time-sharing arrangements will be limited and cannot be employed for all high power operations in Puerto Rico. Nevertheless, the frequency agility of the Gregorian telescope at the Observatory suggests that the Commission do nothing to discourage stations from voluntary cooperative efforts to aid in the significant, far-reaching research being conducted at the Observatory. Indeed, such coordination should be encouraged and endorsed by the Commission as being consistent with service to the public interest.

The Commission does not propose to require applicants to notify the Observatory in advance of filing the following applications: mobile stations in land mobile radio services⁶; temporary base or temporary fixed stations⁷; the Civil Air Patrol; new amateur stations⁸; mobile earth terminals licensed under Part 25; and stations aboard ships or

⁶ Fixed stations in this service, however, would be required to notify the Observatory.

⁷ Short-term temporary broadcast auxiliary operations would be required to notify the Observatory in advance of operations and such stations proposing to operate within the 4-mile (6.4 kilometer) radius of the Puerto Rico Protection Zone would be required to coordinate with the Observatory prior to commencing operations. In emergency situations, these stations may commence operation prior to notification or coordination but coordination and notification must be accomplished as soon as possible thereafter.

⁸ Amateur licensees proposing to operate new beacon and repeater stations within a ten-mile radius of the Observatory (at coordinates of NL 18° 20' 45", WL 66° 45' 12") would be required to notify and coordinate with the Observatory.

aircraft. Cornell has no objection to these exemptions at this time. The Commission also proposes to exempt from the rules any communications facility that operates above 15 GHz. Although initially the Observatory will not operate above 10 GHz, after a period of operational fine-tuning and calibration, the upgraded Gregorian telescope at Arecibo will be able to operate above 15 GHz. Moreover, there is scientific interest in increasing the frequency range beyond 15 GHz. Cornell is willing to accept the 15 GHz limit of the proposed rules **for the present**, but it suggests that Commission commit to revisiting this limit when the Observatory's use of such frequencies begins to pose interference problems in the future. Importantly, one exception to the 15 GHz limit should be addressed. Under the current local zoning regulations, any point-to-point links which bisect the 4-mile radius Puerto Rico Protection Zone are completely prohibited. For this reason, exempting such operations beyond 15 GHz would appear to restrict the protection imposed by the local regulations.

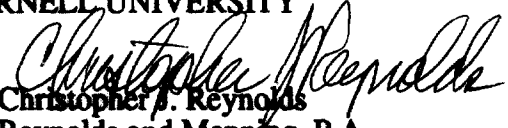
Conclusion

Cornell strongly supports the Commission's proposal to institute a new coordination zone in the Puerto Rican islands. With the increase in sensitivity of the Gregorian telescope at Arecibo, and with the increasing interference conditions, cooperative efforts by communications services and the Observatory could facilitate greatly improved conditions for radio astronomy research and at the same time offer no impediment to provision of communications service on the island. With coordination and time-sharing solutions, even existing facilities can work with the Observatory to improve conditions for researchers. The burdens placed on services affected by the proposed rules to provide the Observatory with copies of their applications and to make "reasonable efforts" to ameliorate any problems are not onerous. The public interest will clearly be served by the institution of procedures to protect radio astronomy research at Arecibo.

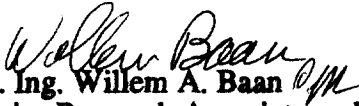
Respectfully submitted,

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March 19, 1996